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Mineral Resource Assessment of the San Bernardino National Forest, California-Executive Summary and a Non-Technical Summary for Land and Resource Managers.

by

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MINERAL RESOURCE ASSESSMENT OF THE SAN BERNARDINO NATIONAL FOREST, CALIFORNIA

Executive Summary

• The San Bernardino National Forest (SBNF) covers 818,999 acres in the eastern San Gabriel, San Bernardino, and San Jacinto Mountains east of Los Angeles, California.

• Several million tons of high-grade carbonate rocks, consisting of limestone and dolomite marble, are mined each year just north of the SBNF for use in the construction, cement, and chemical industries. These rocks continue southward into the national forest and are the unique substrate for five plants that may be identified as endangered species pursuant to the Endangered Species Act of 1973, as amended.

• Geologic, geochemical, and mining data indicate that all of the carbonate rocks within the SBNF have high resource potential for construction-, cement-, and(or) chemical-grade carbonate rocks. At least 1,055 million tons of these rocks are present within the national forest.

• Gross sales from the limestone mines ranged from $180 to 220 million in 1988; sales have increased since then because of increased demand for cement- and chemical-grade products in the Los Angeles metropolitan area. This trend is projected to continue to the year 2000.

• Stream channel and alluvial fan deposits within the SBNF have high resource potential for sand and gravel resources. At least 9,754 million tons of this resource are present within the SBNF and are an important potential source for the construction and concrete industries in the Los Angeles metropolitan area.

• Sedimentary and metamorphic rocks as well as younger plutonic rocks within the SBNF have high resource potential for tungsten vein and skarn deposits, polymetallic replacement deposits, asbestos, and epithermal gold deposits as well as moderate resource potential for gold-bearing quartz veins, gold in polymetallic vein and replacement deposits, iron and tungsten skarns, graphite, and low-grade radioactive mineral deposits. The polymetallic replacement deposits contain lead and zinc ores and may contain gold and silver-bearing minerals. In addition, the Lytle Creek area in the eastern San Gabriel Mountains has moderate resource potential for gold placer deposits. All of these locatable mineral deposits are low grade and(or) low tonnage and do not represent an important resource.

MINERAL RESOURCE ASSESSMENT OF THE SAN BERNARDINO NATIONAL FOREST, CALIFORNIA

A Nontechnical Summary for Land And Resource Managers

DESCRIPTION OF THE STUDY AREA

The San Bernardino National Forest (SBNF) covers 818,999 acres in the eastern San Gabriel, San Bernardino, and San Jacinto Mountains east of Los Angeles, California. These extremely rugged mountain ranges are characterized by numerous alpine lakes and valleys and include several peaks with elevations greater than 10,000 ft (fig. 1). Mining and mineral exploration have played a central role in the history of this national forest and are still important. Deposits of industrial minerals, such as limestone and sand and gravel, as well as locatable minerals such as gold, silver, tungsten, lead, and zinc are common and have been exploited for more than 100 years within the boundaries of this forest.

IMPORTANCE OF THE STUDY AREA

California is the largest cement-producing state in the United States; Portland cement was the state's second most valuable mineral commodity in 1990 with a reported value of more than $604 million. The Lucerne Valley Limestone District, adjacent to the northern boundary of the SBNF (fig. 1), is one of the most important limestone-producing districts in California; gross sales from this district are $180-220 million per year. The carbonate rocks, including limestone and dolomite marble, that are mined and quarried within this mining district continue southward and are present within the SBNF. However, these carbonate rocks are also the unique substrate for five plants that may be identified as endangered species pursuant to the Endangered Species Act of 1973, as amended. To aid land management decision making, the U.S. Geological Survey (USGS) was requested to assess the mineral resources, especially limestone, sand and gravel, and (to a lesser extent) locatable mineral deposits, of the SBNF. This report summarizes the results of that assessment. The geologic, geochemical, and geophysical data from which this summary is derived are described in a separate technical document.

METHODS OF STUDY

All available published and unpublished literature on the geology, geochemistry, geophysics, mining history, and mineral deposits within and adjacent to the SBNF were compiled as of September 30, 1992 and were used to assess the mineral resource potential of this national forest. In addition, new geologic mapping and geochemical studies of carbonate rocks in the Big Bear Lake area, geochemical studies of stream-sediment samples in selected areas, and numerous site visits of sand and gravel deposits throughout the forest were completed by the USGS from 1990 to 1992. Combined, these data define geologic environments with high, moderate, or low mineral resource potential for industrial and locatable minerals. Because the primary emphasis of this study was on limestone and sand and gravel deposits (i.e. industrial minerals), a quantitative assessment of undiscovered locatable mineral resources was not done.

GEOLOGIC SETTING

Eastern San Gabriel Mountains

Rocks in the eastern San Gabriel Mountains include several groups of ancient metamorphic and sedimentary rocks and younger plutonic rocks. Blue-gray mica schist and green-gray chlorite schist are present in the northeastern San Gabriel Mountains and are mapped as the Pelona Schist. These rocks are folded and faulted beneath black platy mylonite that changes texture upward into gray gneissic granite. The Pelona Schist and the overlying metamorphic rocks are Mesozoic in age (see geologic time chart) and are intruded by the Miocene Lytle Creek pluton.

Approximately 7,000 ft of tan quartzite, gray to white marble, and schist in the southeastern San Gabriel Mountains are mapped as part of the Paleozoic(?) Placerita metasedimentary suite. All of these rocks, as well as Precambrian(?) gneiss and lenses of marble, are intruded by Late Mesozoic granitic rocks.

All of these ancient rocks, except the Lytle Creek pluton, are overlain by sedimentary deposits that include the Cretaceous or Paleocene San Francisquito(?) Formation, the lower Miocene Vaqueros(?) Formation, the middle and upper Miocene rocks of Cajon Valley, the lower to upper Miocene Crowder Formation, and the upper Miocene to Pliocene rocks of Phelan Peak. The Lytle Creek pluton, as well as the rocks of Cajon Valley, the Crowder Formation, and the rocks of Phelan Peak, are unconformably overlain by the Pleistocene Howard Formation; this unit grades upward into the

Pleistocene Shoemaker Gravel which is unconformably overlain by Pleistocene and Holocene alluvial deposits.

San Bernardino Mountains

The oldest rocks in the San Bernardino Mountains are gneiss, schist, and quartzite that are intruded by Precambrian granitic gneiss and pegmatite dikes. Combined, these rocks are mapped as the Baldwin Gneiss and are unconformably overlain by metasedimentary rocks north, east, and south of Big Bear Lake. The metasedimentary rocks are divided into a quartzite and a carbonate sequence. The quartzite sequence consists of the Johnnie(?) Formation, the Stirling Quartzite, the Wood Canyon Formation, and the Zabriskie Quartzite and ranges in age from Late Precambrian to Early Cambrian. The carbonate sequence is divided into a dolomite-rich unit unconformably overlain by a limestone-rich unit. The dolomite-rich unit consists of the Carrara Formation, the Bonanza King Formation, and the Nopah Formation; all of these rocks are Cambrian in age. The limestone-rich unit consists of the Devonian Sultan Limestone, the Mississippian Monte Cristo Limestone, and the Permian and Pennsylvanian Bird Springs Formation. Carbonate rocks in the northwestern San Bernardino Mountains are collectively mapped as the Paleozoic Furnace Limestone. These rocks are similar to carbonate rocks near Big Bear Lake but have not been divided into the various dolomite or limestone units.

The Baldwin Gneiss and the younger metasedimentary rocks are intruded by late Paleozoic and Mesozoic plutonic rocks in the San Bernardino Mountains. The oldest plutonic rock is Late Triassic alkalic monzonite that intrudes deformed marble north of Big Bear Lake; Jurassic diorite, quartz diorite, and tonalite are also present in this area. All of these rocks are engulfed by several large Late Cretaceous quartz monzonite batholiths that are exposed over several hundred square miles in and north of the San Bernardino Mountains. Light-gray granitic dikes cut all of these plutonic rocks and may be Tertiary in age.

Tertiary sedimentary rocks are exposed in two areas in the San Bernardino Mountains. The Miocene Santa Ana Sandstone unconformably overlies the Mesozoic granitic rocks and Precambrian gneiss in the central part of the range, and scattered exposures of the Pliocene Old Woman Sandstone unconformably overlie granitic and metasedimentary rocks along the northern front of the mountains. These Tertiary rocks may represent the remnants of a sedimentary "blanket" that covered the San Bernardino Mountains; this "blanket" has been eroded away by younger geologic events.

San Jacinto Mountains

The Desert Divide Group and the Palm Canyon Complex are the oldest rocks in the San Jacinto Mountains. The Desert Divide Group consists of about 8,000 ft of quartz- and carbonate-rich metasedimentary rocks that are divided into the Bull Canyon Formation and the Ken Quartzite. The Bull Canyon Formation consists of gneiss, schist, quartzite, and marble that contains Ordovician conodonts. The Ken Quartzite consists of quartzite with rare lenses of marble, schist, and gneiss. The Palm Canyon Complex consists of pelitic schist, gneiss, marble, and metasedimentary rocks. Except for the lack of quartzite and different metamorphic mineral assemblages, these metasedimentary rocks are similar to metasedimentary rocks in the Desert Divide Group.

The Desert Divide Group and the Palm Canyon Complex are intruded by plutonic rocks of the Middle Cretaceous Peninsular Ranges batholith. The oldest rocks in this bâtholith are quartz monzonite and hornblende gabbro; the quartz monzonite is cut by northeast-trending aplite and pegmatite dikes as well as a few quartz veins. These rocks are intruded by tonalite, monzogranite, and granodiorite that grade eastward into strongly deformed mylonitic rocks and are faulted beneath Cretaceous granitic rocks and tonalite. All of these plutonic rocks are unconformably overlain by fanglomerate deposits of the Pleistocene Bautista Formation.

RESULTS

Carbonate Rocks

Carbonate rocks are an important commodity for the construction, cement, and chemical industries. The classification and resource potential of these rocks are primarily a function of color, the amount of lime, magnesia, and silica in the rock, and the proximity to markets. Generally, construction-grade carbonate rocks are darker, contain more impurities, and have a lower unit value than do cement-grade carbonate rocks; chemical-grade carbonate rocks are white, bright, and contain less than 2 percent impurities. Geologic and mining data, combined with information on the supply and demand outlook for carbonate rock resources to the year 2000, indicate that all of the carbonate rocks within the SBNF have high resource potential for construction-grade carbonate rocks (fig. 2). An estimate of this resource, as well as cement- and chemical-grade carbonate rocks within the SBNF, is listed in table 1. Many of these rocks, including the Furnace Limestone in the eastern San Gabriel and the San Bernardino Mountains, the Nopah Formation and the lower member of the Sultan Limestone in the San Bernardino Mountains, and marble in the Desert Divide Group in the San Jacinto Mountains, have been quarried for roofing granules or other construction stone for many years.

Geochemical data, combined with geologic and mining data, indicate that marble in the Desert Divide Group as well as the lower and the middle members of the Bird Springs Formation have high resource potential for cement-grade carbonate rocks. In addition, white marble from the Bonanza King Formation and marble near intrusive contacts in the Nopah Formation have high resource potential for use as cement-grade carbonate rocks.

Geologic and geochemical data indicate that the upper member of the Sultan Limestone and the middle member of the Monte Cristo Limestone have high resource potential for chemical-grade carbonate rocks. The lower member of the Monte Cristo Limestone also meets the chemical specifications of cement- and chemical-grade carbonate rocks and has high resource potential for use in these applications. However, this member consists of gray and black cherty limestone with many chert lenses, layers, and nodules. The abundance of silica suggests that the lower member could be quarried for cement- or chemical- grade rocks, or it could be quarried and stockpiled to blend with other carbonate rocks to obtain the required color, brightness, or chemical composition of a hybrid product.

Sand and Gravel

All unconsolidated sedimentary deposits within the SBNF are possible sources of sand and gravel but only a few can be exploited. The resource potential of this commodity is dependant on quantity and average grain size of the deposit as well as proximity and transportation costs to markets. Given these criteria, sedimentary deposits in the Cajon Canyon and Lytle Creek areas in the eastern San Gabriel Mountains, the Santa Ana River area near Barton Flats, the Silverwood Lake, and Smart's Ranch areas in the San

Bernardino Mountains, and the San Jacinto River area in the San Jacinto Mountains have high resource potential for sand and gravel resources (fig. 2). Although an estimate of the resources for each mountain range is listed in table 1, testing and economic evaluation is necessary to determine the quality of each deposit.

Locatable Minerals

Geochemical anomalies and the location of existing mines indicate that tungsten vein deposits occur in gneiss, schist, and quartz diorite near faults in the northeastern San Gabriel Mountains. Pods of lead and zinc minerals also occur along fault zones in this area as well as along the contacts between carbonate and plutonic rocks throughout the eastern San Gabriel Mountains. These mineralized pods are similar to polymetallic replacement deposits that typically contain silver, lead, zinc, and gold. Combined, the geologic, geochemical, and mining data indicate that the eastern San Gabriel Mountains have high mineral resource potential for tungsten vein deposits and polymetallic replacement deposits. In addition, Lytle Creek and its tributaries has moderate resource potential for small gold placer deposits (fig. 2).

Geologic, geochemical, and mining data indicate that metasedimentary roof pendants and the adjacent plutonic rocks in the San Bernardino Mountains have moderate mineral resource potential for gold and graphite. The gold occurs in quartz veins and in polymetallic veins and replacement deposits; the graphite is concentrated along faults within the roof pendants. In addition, the contacts between carbonate rocks in the roof pendants and the plutonic rocks have moderate mineral resource potential for iron and tungsten skarns. Finally, gneiss and pegmatite dikes in the Baldwin Gneiss have moderate mineral resource potential for low-grade radioactive mineral deposits (fig. 2). Although known uranium and(or) thorium deposits are rare, geochemical and scintillation studies suggest that anomalous concentrations of radioactive minerals are present in this area.

Geologic and mining data indicate that carbonate rocks in the Desert Divide Group in the San Jacinto Mountains have high resource potential for tungsten skarn deposits where these rocks are intruded by granitic rocks of the Peninsula Ranges batholith. The only known gold mineralization in this area occurs in otherwise barren quartz veins and pegmatite dikes in the Desert Divide Group where it is intruded by quartz monzonite. These data indicate that quartz veins and pegmatite dikes in the Desert Divide Group and the adjacent plutonic rocks have high resource potential for mesothermal gold deposits (fig. 2).

Lenses of amphibolite in the Palm Canyon Group are locally altered to slip-fibre asbestos and have high mineral resource potential for asbestos deposits. One of these deposits produced about 800 tons of asbestos in the 1930's for use in automobile battery boxes.

OUTLOOK

Although demand for construction-, cement-, and chemical-grade carbonate rocks is projected to increase at a moderate rate of 2 to 4 percent per year through the year 2000, the greatest growth is expected for carbonate-based whitenings in the paper, paint, and plastic industries. Currently the amount of carbonate filler in the American paper industry ranges from 7 to 12 percent and is projected to increase to 30 percent by the end of this decade. Domestic production is expected to meet more than 99 percent of this demand if zoning restrictions and environmental concerns do not curtail limestone mining within the SBNF.

The California Division of Mines and Geology (CDMG) divided the Los Angeles metropolitan area into six sand and gravel production-consumption regions based on the assumption that production of sand and gravel resources within each region would most likely be consumed within that region. The Division's projections suggest that only one of the six regions has reserves nearly equaling the anticipated demand for the next 50 years; the supply of sand and gravel resources within the other five regions falls far short of demand. However, the sand and gravel resources within the SBNF were not included in CDMG's projections and will mitigate any projected shortages for several decades.

Mining for locatable minerals in the SBNF began in the early 1800's and has continued sporadically to the present day. Although more than 53,000 oz of gold was produced from the SBNF during this time, the geologic, geochemical, and mining data indicate that all of the known locatable mineral deposits within the SBNF are either low grade or low tonnage and do not represent an important resource. It is unlikely that large undiscovered locatable mineral deposits are present within this national forest.

Table 1. Industrial mineral resource estimates (in millions of tons) of the SBNF

Carbonate Rock Resources	
Construction Grade	1,015
Cement Grade	80
Chemical Grade	60
Total	1,055
Sand and Gravel Resources	
San Gabriel Mountains	3,517
San Bernardino Mountains	1,837
San Jacinto Mountains	4,400
Total	9,754

Note: These are minimum estimates because the areal extent, thickness, and geochemistry or grain size of all favorable horizons are not known.

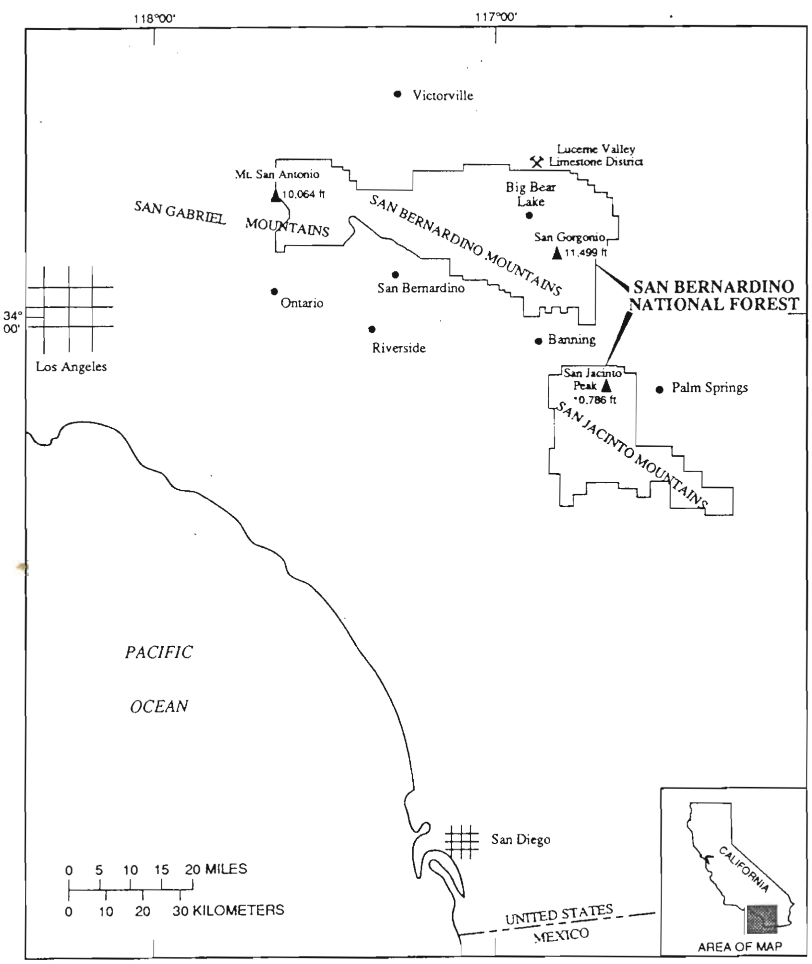

Figure 1. Index map of the San Bernardino National Forest, California.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES (in Ma)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	[1]~570
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				
- - - -	- - - -	- - - - (3800?) -	- - - -	- - - -	
pre-Archean[2]					4550

[1]Rocks older than 570 Ma also called Precambrian, a time term without specific rank.
[2]Informal time term without specific rank.

Figure 2. Mineral Resources of the San Bernardino National Forest, California